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EXPERT BASED RAPID ANNUNCIATIONS AND CONTROLS IN DISASTER MITIGATION

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Abstract - **Disaster Management Systems are in practice which exhaustively involve ICT based framework and are serving the purpose. However, an immediate assessment of the situation and effective actions plans to limit the fatal-chaining-effects of the adversity need be acted upon. This paper presents a methodology for annunciation and control to reduce the spreading effect of Disaster and thus enabling its effective management. The approach encompasses mobile technology, GIS and expert control for DM. This methodology will be very much useful for the development of a comprehensive Disaster Management System. Thus proving it time effective and accurate in deploying the resources involving a disaster mitigation knowledge base.**

Keywords - **Expert System, Disaster Management, Emergency Control, Mitigation, ICT, Adversity**

I. INTRODUCTION

Disaster throws many challenges to mankind and its wide spectrum nature further contributes to multiply. Various developments emanating from the human desire for more comfort and luxury, crowding of cities, abusing nature, handling/storing hazardous materials etc., show its effects in nature in the form of its catastrophic events. For any society, the most precocious asset is to protect the life of the people and the resources created. As the technologies advanced Disaster Management (DM) techniques have also been evolving for long. Since no unified efforts have been done, different technology based approaches have been adopted over and again. Only recently, ICT researchers are utilizing available infrastructures like - the internet, network, traffic management systems etc. [1] [2] [3], in various ways. Such approach would make DM slow in response, fragmented and heavy to manage. It is commonly observed from the past cases that trivial delays and unorganized/ uninformed response to an adversity would result into unsatisfactory management and poor mitigation of disaster.

The utmost challenge during adversity is to get its first-hand information immediately in a right perspective, in order to be able to plan actions and generate quick alerts for various concerned agencies as well as Actors [4]. The delays of any sort may exponentially increase the fatality because of its multiplying effects [5]. Further, if control of various critical services like gas supply, electricity etc. are achieved at the occurrence of the fatal event, it will not only reduce the impact of the adversity but will greatly help in mitigating the chain-disasters.

Today, the technology is pervading all walks of life and being used for connecting people in a meaningful way. Also, technology is being used to monitor and manage the traffic. In this scenario, however, events occurring - leading to some kind of adversity (or disaster) are not being taken forward in a meaningful manner. In other words, no proper notification tools are being used. Thus, a miscommunication, improper communication and succeeding misinterpretation of the event would lead to the entire management plan to an indecisive state.

Therefore, we identify the first challenge as to perform an immediate and accurate assessment with precise information about the disaster - its cause, location, time etc., in the first place. A proposition here for the future developments, where we can expect that the entire area equipped and spanned with the smart sensor networks, to gather first-hand information of the fatal event, would be a very costly affair[6]. Alternatively, in this work we propose to involve society (a subject, mostly equipped with the internet enabled mobile devices) as a preliminary trigger (referred as Initial Disaster Information – IDI in this work) about the disaster and further making them aware of responding immediately against any adversity they observe.

Thus, the effectiveness of DM can be achieved if the right location and the type of the adversity are comprehended by the observer (subject) and communicated in a useful way to the DM control centre. Immediately, this could lead to right annunciations and controls to limit the expanding boundaries of the event. For this, universally accepted the address for a location can only be expressed in terms of its latitude and longitude. Thanks to the mobile technology and internet that has encompassed the society tightly and enabling them with its unique geographical information features. We propose to develop and use a mobile

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application for this purpose. However, an added verification of the situation (discussed later in section IV) is also introduced as the observer at the location may not be able to give all the required details of the vicinity.

Next important task is to efficiently mobilize and schedule various resources for immediate recovery. This is similar to the resource distribution and scheduling problem for which various Tabu search and other techniques have been proposed [7][8], which could be considered as a good candidate in DM. However, in the case of disaster management, it needs initiation of immediate actions while these methodologies of scheduling would delay actions for more than an hour or so, and is not desirable [9].

Therefore, in the case of DM, knowing the disaster perspective as first-hand information, initiation of primary controls to avoid the spread of effects and immediate deployment of actors (person, resource, agency, member etc.) in a planned manner is essential to address DM. Further emergency management inherently is a complex process and would need experienced /trained professionals to plan for DM and deploying distributed / heterogeneous teams with different expertise to take charge of DM. In practice, this becomes difficult and makes the DM a good case for an Expert System. Researchers have used ES in the disaster situation for the purpose of evacuation from the disaster site [10]. The size of ES may be large in such cases. Keeping this fact in view we have conceptualized the proposed system as staggered ES; where the first part would be of the minimal size to enable initial "annunciations and triggering of resource mobilization" so that no large delays are involved before more comprehensive actions are lined up.

As mentioned above, to generate the perspective of the affected site, we developed "one touch emergency intimation mobile application" thereby passing relevant information including the geographical location of the adversity to the control centre. This is achieved through a "subject (observer)". We use this first-hand information to assess the disaster prone area and to initiate necessary alerts and controls using an ES.

Here we have adopted the Geographical Information System (GIS) to comprehend the scenario of the disaster location [11]. It is obvious that disaster has a tendency to start with a nucleus and then may spread aggressively affecting more areas, if not controlled immediately. So, in this context, if the "susceptible area" is known in advance then the DM experts can make an action plan to initiate and deploy the task force [12].

II. CONCEPTUAL PARADIGM

In this work the basic concept is to initiate disaster mitigation actions with minimal time as a first step. The following functional diagram depicts the conceptual model and the relations between the modules.

The knowledge is in a state which represents the availability of past disaster's situational data in terms of disaster types and the resources utilized [12]. This state is always in update mode and updated timely with the latest information available. This state has a great value in the proposed design which enables first-hand deployment of resources.

The another functional state is that of ES. The first module of the ES is responsible for taking the GIS data with respect to IDI. Then firing various annunciations & controls to stop chain disasters and triggering resources to mobilize in the disaster area as per the priority decided.

The following section presents an Android application developed to get the first set of disaster information.

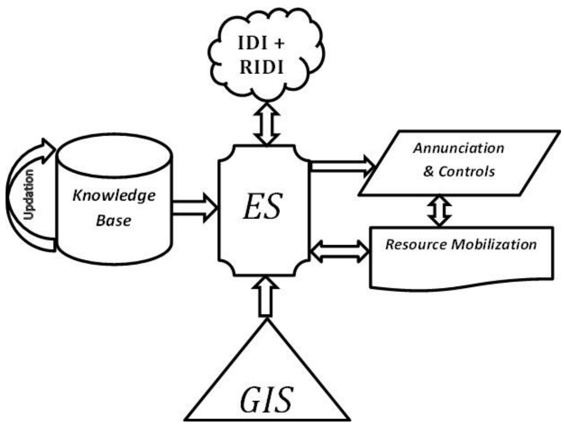

Fig. 1: Conceptual Model of ES

III. INITIAL DISASTER INFORMATION (IDI)

3G and 4G technologies are transforming the conventional mobile communication to an all-inclusive integrated internet (Web 2.0). They have now become very handy, smart and easy to use in social, academic, business as well as in emergency situations. Android open platform OS has drawn huge attention due to its versatility and portability.

In the present research, to achieve the DM objective, we have resorted to develop a mobile aid using android which is to be installed on the mobile devices. The aid on the mobile is menu based and is able to send "IDI" to the DM control centre, the IDI may also include disaster nuclei perspective - as is observed by the subject (observer) in the affected area (like cause, magnitude etc.) and the geographical information like latitude, longitude & time. Details of the same are depicted in Fig. 2 - The Screen Shots. When activated, this not only will transmit the information to the control centre but to other concerned agencies too.

It may be noted that this information will be coming from the observer(s) in the area and thus may require added verification. However, this IDI, at the control centre, becomes the first trigger to initiate the DM action plan.

The verification referred as Redefine Initial Disaster Information (RIDI) in this paper can be substantiated by an

Actor of DM team. In the following, we propose a process (refer Fig. 3) to enable this.

Fig. 2: The Screen Shots

As soon as the IDI is received from any Subject in the affected area, the control centre will generate an “ALERT” to all the “Actors” informing about the emergency situation. In other words, the control centre will generate a query which will request the actor(s), which is in the vicinity of the disaster area, for RIDI, the verification, and refining of IDI. This is to ascertain the cause of the disaster and its magnitude to enhance the effectiveness of DM. The control centre would always have the locations of the associated actors through the GPS. In the absence of any Actor in that area, the control centre would continue with the IDI sent by the Subject. Having followed this process the control centre activates its Disaster Management Planning and is discussed further.

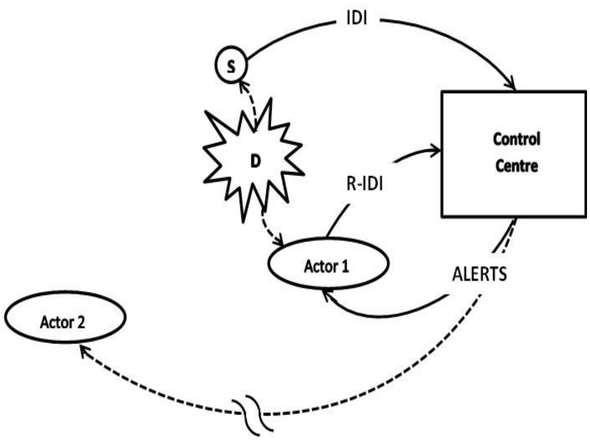

Fig. 3: R - IDI Process

IV. DISASTER SCENARIO & MANAGEMENT PLANNING

The disaster management planning would need detailed information about the objects surrounding that area. In today’s time, with the advancement of the technology, such information is becoming available through the GIS (example from “Survey of India”) [13]. This work presents a methodology to extract the information and plan the DM.

A. GIS map compatibility & output data format

Let us consider that the GIS maps represent the details of an area of the land in a matrix form as given in the fig. 4.

Where following representations are given as:

A: Apartment/House

B: Bridge

C: Community Center

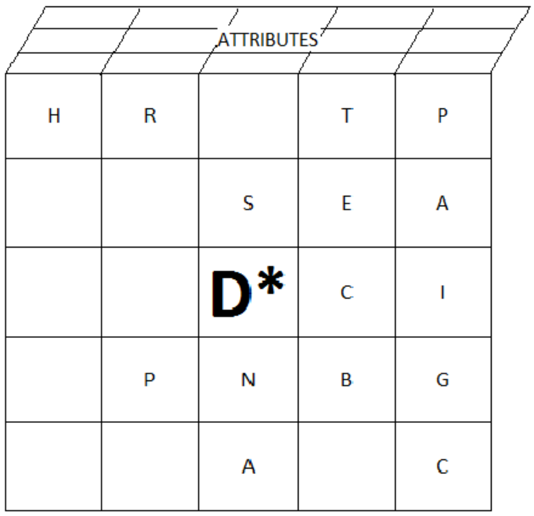

Fig. 4: GIS Map Format

E: Electric Substation

G: Gas Pipeline

H: Hospital

I : Industry

P: Petrol Pump

R: River / Pond

S: School/College

T: Track-Rail-Road

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Here D* represents the Nuclei of the disaster area whose latitude and longitude have been received from the IDI Application.

B. Disaster Type

As such we do know that the disasters could be of varied nature and for the simplicity, we hereby list few of them as Fire, Flood, Earthquake, Bomb Explosion, Rail or Road Accident, Storm, Volcano Eruption, Bio Hazard, Tsunami, Drought, Industrial Accident or Hazard etc. The subject (observer) may be sending IDI from any location along the way (line) of a disaster. And the DM will have to take into consideration the propagation effect of the affected area. Some of them, like Tsunami, would need a forecasting mechanism for effective DM, this situation is not being considered here in the present context.

C. Resource Types (Actors)

We also know and assume that, in case of disaster, the most valuable resources are usually the Fire Brigade (Fire-Fighter), Hospital(Ambulance), Communication Setup, Transport Facility – Food / Clothing / Shelter, Police & General Administration etc. Having given the above scenario, it is essential to establish an effective co-relation between GIS data and Resources to fight the Disaster as given in fig. 5.

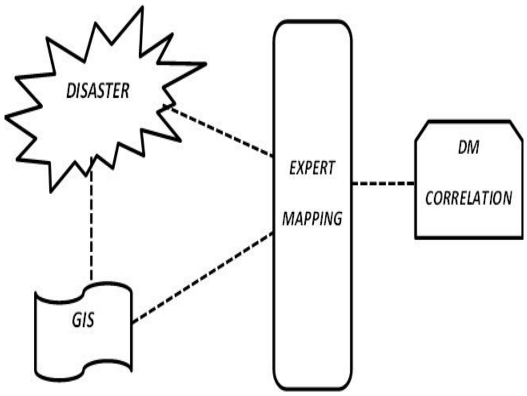

Fig. 5: DM Correlation

V. EXPERT SYSTEM FOR RAPID ANNUNCIATIONS & CONTROL ACTIVATION

In the Matrix above (Fig. 4), let the disaster nucleus cell be as Z(0,0) and all other nearby cells can be called as Z(i,j), and Z(i,j) is a vector of attributes of that cell which can be accessed through CELL FRAME. Thus, each cell has its own attributes stored as a vector (refer fig.4). So Z(1,0) represent a Community Centre and Z(0,-2) is an Apartment/House etc. Thus, in totality, this matrix becomes an input data for the Expert mapping. A CALL function in PROLOG (SWI-Prolog) helps to input this data. The next level program will read all the attributes of the Disaster and its nearby cell by reading the CELL FRAME (Fig. 6) and will be able to map the entire adversity prone area. For example, referring the vector below, it may be noted that a gas pipeline is passing through the concerned area. The ES, through its inference, is now supposed to block/bypass/stop the gas supply so as to inhibit /control/limit the effects of the hazards. Similarly, other control actions can be initiated in the first place by the control centre.

In the DM, the next activity is to save the lives. Therefore, here we have taken the population density as a parameter to decide the priority of the resources to attend a cell as given in priority matrix (Fig. 7).

For example, pre-defined activities like students in a school, registered in the cell, may require Actors (resources) to be physically made available at victim spot. Considering this and the previous one, we require the expert system that could generate all the necessary guidelines for various Actors. An ES logic, as an example, is presented in the following.

FACETS

Cell(x,y)	Value	Default	Updated
Population	High	X	-
Building	School	Y	-
Pipeline	Gas	Z	-

SLOTS

Fig. 6: Cell Frame

Z(0,2) P:5		Z(0,2) P:7	Z(0,2) P:1	
			Z(0,2) P:2	
Z(0,2) P:6	Z(0,2) P:4	Z(0,0)		
			Z(0,2) P:3	

Fig. 7: Cell Priority Matrix

Like “ordering” the gas supply agency to “shut off” the gas supply which is passing through the disaster area under consideration; “informing” the electricity board to “cut off” the electric supply through their grid from appropriate junctions if the high tension line is passing through the disaster area; or police may be “asked” to “divert” the traffic appropriately so that no congestion or accidents take place in that area.

These expert actions not only will stop chain disasters but will also greatly help to mitigate and recover the present disaster in a very low time span. Also, the ES will read appropriate resource(s) from the knowledgebase as given in Table 1 and Table 2 [12] to initiate appropriate actions for the deployment of resources.

TABLE 1. DISASTER CLASSIFICATION ACCORDING TO THEIR CONSEQUENCES

Disaster Type / Disaster Parameter	D(n) → / P(i) ↓	D_1	D_2	D_3	D_4	D_5	-	D_N
Time of Occurrence	P(1)	L	L	M	H	L	-	L
Location	P(2)	H	M				-	L
Area Coverage	P(3)	M	H				-	H
Climatic Condition	P(4)	L					-	M
Population at Risk	P(5)	M					-	L
Infrastructure at Risk	P(6)	M					-	H
Fire	P(7)	M					-	M
Damage of Utilities							-	
(a) Electricity	P(8)	L						L
(b) Water	P(9)	H						L
(c) Road	P(10)	M						M

----------	P(r)	-	-	-	-	-	-	M

TABLE 2. ALLOCATION OF RESOURCES ON THE DISASTER MANAGEMENT TIME CYCLE

Time / Disaster	T_1	T_2	T_3	T_4	T_5	T_6	T_K
D_1	{R_2,R_3,R_6,R_9,R_{10}}	{R,R,R,R}	{R,R,R}		-	{R,R,R,R}	{R,R,R}
D_2	-	{R,R)	{R,R,R}	{R}		{R,R,R}	{R}
D_3	{R_1}	-	{R,R}	{R}	{R,R}	-	
D_4	{R_2,R_4,R_5 R_7}	{R}		{R,R,R,R}		{R}	{R,R,R}
D_5	{R_1,R_2}	{R,R,R,R,R,R}	{R,R,R}	{R,R,R,R,R,R}		-	
D_6	{R_3,R_4,R_6}	-	{R,R,R}		-	{R,R,R,R}	{R}
-	-	{R,R,R,R,R,R}	{R,R}	{R}	{R,R,R}		
D_N	{R_5}	{R,R,R,R}	-	{R,R,R}	{R}	{R,R,R}	{R,R}

The following section depicts a part of the expert system applicable to a situation under consideration.

A. *Disaster Case*

Let us now take a case of an earthquake. In our example, we have assumed that there is a school and a gas pipeline in the nearby cells of the nucleus and rest nearby cells are not having any entity.

B. *ES Module*

As an example, let us assume that there is a school in the cell Z(0,1) and a gas pipe line in the cell Z(2,-1). Considering these the pseudo-code for expert program is as follows:

```
%This is the First Module of ES
%Top Goal- system will ascertain the disaster, disaster type
%Initiate controls and resource movements
START
%IDI–Initial Disaster Info from Subject
SEE ('IDI')
READ('DisasterType','Latitude','Longitude')
      Nucleus = Nucleus (Latitude, Longitude)
WRITE ("ALERT for All Actors")
GET ("GIS Location of All Actors")
%Get Geo-location of actors using Prolog
%spatial index
COORDINATE (?Actor(n), ?Long, ?Lat)
%Get Re-confirmation of the IDI from actors
CALL ('R_IDI')
QUERY ("What is the Disaster?")
Disaster (x):- Menuask (Disaster, x,
                  [earthquake, bomb, flood,…….])
QUERY
("What is Magnitude", "What is  Time",…….)
…………………………
%On the basis of these parameters, disaster type is defined
%As explained in [12]
RESULT ("Disaster" = Dn)
%Get resource allocation on time cycle
%As explained in [12]
Get (Resource_Allocation)
Working Storage Facts:
FRAME:
Get_Frame (Cell(i,j),
     [Population-P, Building-B, Pipeline-L])
     P = High; B = School; L = Gas;
%Using system library compares cell population
%And generate priority table
Compare (Cell_Population)
Write (Priority_Cell)
Get_Frame(Resource,
     [Ambuance, Firebrigade, Gas Station])
%Output data
CALL (Ambulance, Fire-brigade, ………)
TELL (Priority_Cell, Resource_Allocation)
%Initiate Controls
If        Disaster(x):- Earthquake
ShutOff GasLine /\ Stop WaterValve /\ CutOff -Electricity
If        Time (t):- Day
Tell (School, "Evacuate")
If        Environment_Temperature > 45^0 C
WRITE ("FIRE ALERT")
READ (Cell(x,y), Cell_Status)
IF        Cell_Status = OK
RESTORE GasLine Λ Electricity Λ Traffic
END
```

VI. CONCLUSION

Early and appropriate information / perspective about the occurrence of a disaster to the control centre can play a vital role in limiting the spread of the disaster. Proper planning of actions there on can further help coordinate the teams in a right manner. This paper presented a methodology using available mobile services for inward information and planning. GIS and disaster data are mapped using an ES to ease out immediate planning with increased competence in DM. In future, as the technology is absorbed into the society, sensor networks/ CCTV etc., could be used further to gather more information of the affected area. The proposed system is easy to deploy and use. The authors also propose to use this mapped information in further work for its use in a flexible resource planning, scheduling, and deployment for a comprehensive DM system.

VII. REFERENCES

[1] Y. Maeda, M. Higashida, K. Iwatsuki, T. Handa, Y. Kihara and H. Hayashi, "Next Generation ICT Services Underlying the Resilient Society, Journal of Disaster Research, Vol. 5, No. 6, 2010, pp. 627-635.

[2] M. Kondo, "ICT and Disaster Management", Director for North America, Europe, and ITU Affairs International Policy Division, Ministry of Internal Affair and Communications, Japan, 2011.

[3] J. Munodawaf, " Role of Telecommunications and ICTs in Disaster Management", ITU Southern and East Africa Workshop on the use of Telecommunications/ICT for Disaster Management, Lusaka, Zambia, 2008.

[4] P.K. Chande, R. Sodhani, Y. Maheshram, A.K. Goyal, ICT (Information and Communication Technology) driven adaptive C3 (Collaboration - Coordination - Cooperation) - M3(Man-Machine-Management) Framework in Emergency, TIEMS (The International Emergency Management Society) 18^{th} Annual Conference on Natural and Technological Risk Reduction through Global Cooperation at Bucharest, Romania, 2011.

[5] C. Scawthorn, Y. Yamada and H. Iemura, "A model for urban post-earthquake fire hazard", The International Journal of Disaster Studies and Practice, Vol. 5, No.2, 1981, pp. 125-132.

[6] C. Yawut and S. Kilaso, "A Wireless Sensor Network for Weather and Disaster Alarm Systems", International Conference on Information and Electronics Engineering, Vol. 6, 2011, pp. 155-159.

[7] M. Gendreau, G. Laporte and R. Seguin, "A Tabu Search Heuristic for the Vehicle Routing Problem with Stochastic Demands and Customers", Operations Research, Vol.44, No.3, 1996, pp. 469-477.

[8] N. Kokash, "An introduction to Heuristic Algorithm", Trento:s.n., 2005.

[9] J.R. Crino and J.T. Moore, "Solving the Theater Distribution Vehicle Routing and Scheduling Problem Using Group Theoretic Tabu Search", Mathematical and Computer Modelling, Volume 39, Issues 6–8, 2004, pp. 599–616.

[10] M. Osorio, C. Zepeda, D. Sol and G. Lazzeri, "A Decision Support System for Disaster Situations", Research on Computing Science e-Environment: Progress and Challenge. Mexico: IPN, Mexico, volume 11, 2004, pp. 97-116.

[11] S. Zlatanova1 and A.G. Fabbri, "Geo-ICT for Risk and Disaster Management", Scholten, van Velde, van Manen (eds) Geospatial technology and the role of the location in science. Springer, Dordrecht, Heidelberg, Londen, New York, 2009, pp. 239–266.

[12] R. Sodhani and A.K. Goyal, "ICT Driven Resource Mapping & Triggering using 3Cs for Disaster Management", International Journal of Innovations in Engineering & Technology, Vol. 2, No. 3, 2013, pp. 117-121.

[13] S. Mogere and T. Schlüter, "Utilization Of Geographical Information System (GIS) For Effective Management", Geological Atlas of Africa (Book), Springer Berlin Heidelberg, 2006.